Online Appendix to Offshore Dollar Funding Shocks and the Dollar Exchange Rate*

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Appendix

In this appendix, equation references that are preceded by a letter refer to equations in the appendix. Those not preceded by a letter refer to equations in the main text of the paper.

A Period 2 Goods Market Equilibrium

Country h households receive an endowment of $Q_{h,2}$ of the good of country h. The period 2 consumption index for households from country h is

$$C_{h,2} = \left((0.5)^{\frac{1}{\theta}} C_{hH,2}^{\frac{\theta-1}{\theta}} + (0.5)^{\frac{1}{\theta}} C_{hF,2}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{A.1}$$

Here $C_{hH,2}$ is consumption of the Home good by country h households and $C_{hF,2}$ is consumption of the Foreign good by country h households. The parameter θ is the elasticity of

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substitution among the two goods. Central banks target a price of $P_{H,2} = 1$ for the Home good in dollars and a price of $P_{F,2} = 1$ for the Foreign good in euros. The price index of consumption in dollars is then

$$P_2 = \left(0.5 + 0.5 S_2^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{A.2}$$

and the price index in euros is $P_2^* = P_2/S_2$. The standard intratemporal first-order conditions imply consumption of Home and Foreign goods of

$$C_{hH,2} = 0.5 \left(\frac{1}{P_2}\right)^{-\theta} C_{h,2} \tag{A.3}$$

$$C_{hF,2} = 0.5 \left(\frac{S_2}{P_2}\right)^{-\theta} C_{h,2} \tag{A.4}$$

for agents from both countries.

The "other" agents (CIP arbitrageurs and UIP arbitrageurs) have the same consumption index. Using the expressions for the supply Q_H and Q_F of Home and Foreign goods, period 2 goods market clearing then implies

$$e^{\kappa_H \epsilon_q} = 0.5 \left(\frac{1}{P_2}\right)^{-\theta} (C_{H,2} + C_{F,2} + C^o_{H,2}) \tag{A.5}$$

$$e^{-\kappa_F \epsilon_q} = 0.5 \left(\frac{S_2}{P_2}\right)^{-\theta} (C_{H,2} + C_{F,2} + C^o_{H,2}) \tag{A.6}$$

Denote with a bar the levels of second period consumption when $s_2 = 0$, so that $S_2 = 1$. In that case $P_2 = 1$. Linearizing (A.5)-(A.6) around $\epsilon_q = s_2 = 0$, we get

$$1 + \kappa_H \epsilon_q = 0.5(C_{H,2} + C_{F,2} + C^o_{H,2}) + 0.25(\bar{C}_{H,2} + \bar{C}_{F,2} + \bar{C}^o_{H,2})\theta s_2$$
$$1 - \kappa_F \epsilon_q = 0.5(C_{H,2} + C_{F,2} + C^o_{H,2}) - 0.25(\bar{C}_{H,2} + \bar{C}_{F,2} + \bar{C}^o_{H,2})\theta s_2$$

First set $\epsilon_q = 0$. It follows immediately by first subtracting and then adding these equations that $s_2 = 0$ and

$$\bar{C}_{H,2} + \bar{C}_{F,2} + \bar{C}^o_{H,2} = 2 \tag{A.7}$$

Using this equation, taking the difference between the two market clearing conditions (using $\kappa_H + \kappa_F = 1$) gives $\epsilon_q = \theta s_2$ or $s_2 = \epsilon_q/\theta$.

B Pre-Shock Equilibrium

Period 1 variables are equal to period 0 variables in the pre-shock equilibrium. For the exchange rate this implies $s_1 = s_0 = 0$. This also implies that $P_1 = P_1^* = 1$. Consumption is smoothed in that period 1 consumption by households is equal to period 2 consumption when $s_2 = 0$. We denote pre-shock period 1 variables with a bar. They are equal to corresponding period 0 variables.

In the pre-shock equilibrium household wealth is the same in period 1 as in period 0. This implies that saving of Home and Foreign households is zero, so that

$$\bar{C}_{H,1} = \bar{Y}_{H,1} + \bar{\Pi}_{HCB,1} + i^{\$} W_{H,0} \tag{B.1}$$
$$\bar{C}_{F,1} = \bar{Y}_{F,1} + \bar{\Pi}_{FCB,1} - i_0^{\$,syn} D_{F,0}^{\$,syn} - i^{\$} D_{F,0}^{\$} - i^{\$,swap} D_{swap,0}^{\$} + i^{€} B_{F,0}^{€} \tag{B.2}$$

This sets period 1 consumption equal to income, which is the sum of income from production and interest income and transfers of central bank profits back to the households. Here $\bar{\Pi}_{HCB,1} = i^{\$} M_0^{\$}$ and $\bar{\Pi}_{FCB,1} = i^{€} M_0^{€}$. One of these equations is redundant as aggregate world saving is zero. We therefore remove the last equation.

In the pre-shock equilibrium we also have consumption smoothing: $\bar{C}_{h,1} = \bar{C}_{h,2}$. Substituting this into the period 2 budget constraints, we have

$$\bar{C}_{H,1} = 1 + \bar{\Pi}_{HCB,2} + \bar{M}_{H,1}^{\$} + (1 + i^{\$}) \bar{W}_{H,1} \tag{B.3}$$
$$\begin{aligned} \bar{C}_{F,1} &= 1 + \bar{\Pi}_{FCB,2} + \bar{M}_{F,1}^{\$} + \bar{M}_{F,1}^{€} + (1 + i^{€}) \bar{W}_{F,1} \\ &\quad - (\bar{i}_1^{\$,syn} - i^{€}) \bar{D}_{F,1}^{\$,syn} - (i^{\$} - i^{€}) \bar{D}_{F,1}^{\$} - (i^{\$,swap} - i^{€}) \bar{D}_{swap,1}^{\$} \end{aligned} \tag{B.4}$$

The last two equations needed to derive the pre-shock equilibrium are

$$\bar{C}_{H,1} + \bar{C}_{F,1} + \bar{C}_{H,1}^{o} = 2 \tag{B.5}$$
$$\bar{B}_{CIP,1}^{\$} = \bar{D}_{F,1}^{\$,syn} \tag{B.6}$$

These correspond to the period 2 world goods market equilibrium (A.7), replacing $\bar{C}_{h,2} = \bar{C}_{h,1}$, and the period 1 swap market equilibrium. We then have a total of 5 equations: (B.1) and (B.3)-(B.6). This system can be solved by substituting expressions for money balances, portfolio holdings, central bank profits and period 1 production, setting $\bar{i}_1^{\$,syn} = i_0^{\$,syn}$, $s_1 = s_0 = 0$, $\bar{D}_{F,1}^{\$} = D_{F,0}^{\$}$, $\bar{D}_{swap,1}^{\$} = D_{swap,0}^{\$}$ and $\bar{W}_{h,1} = W_{h,0}$. We then have 5 equations in 5 variables: the 2 period 1 consumption levels, the 2 initial wealth levels $W_{h,0}$ and $\overline{cip}$. As shown in the Online Appendix, after these substitutions, we obtain 5 equations in $\bar{C}_{H,1}$, $\bar{C}_{F,1}$, $W_{H,0}$, $W_{F,0}$ and $\overline{cip}$.

Omitting period 0 and 1 time subscripts, the synthetic dollar borrowing by European households in the pre-shock equilibrium is

$$\bar{D}_F^{\$,syn} = \rho + \bar{M}_F^{\$} - \bar{D}_F^{\$} - \bar{D}_{swap}^{\$} - \frac{\overline{cip} + i^d}{\Gamma_F} \tag{B.7}$$

where $i^d = i^{\$} - i^{€}$. Substituting (B.7) into the swap market equilibrium $\bar{D}_F^{\$,syn} = \bar{B}_{CIP}^{\$}$, where $\bar{B}_{CIP}^{\$} = \overline{cip}/\Gamma_{CIP}$, we have

$$\overline{cip} = \frac{\Gamma_{CIP}}{\Gamma_{CIP} + \Gamma_F} \left[\Gamma_F \left(\rho + \bar{M}_F^{\$} - \bar{D}_F^{\$} - \bar{D}_{swap}^{\$}\right) - i^d\right] \tag{B.8}$$

We will assume that the term in the square brackets in (B.8) is positive, generating a positive CIP deviation as seen in the data since 2007. In the limit when $\Gamma_{CIP} \to 0$ this positive CIP deviation approaches zero. This is the case of perfect CIP arbitrage.[1]

When $\Gamma_{CIP} > 0$, positive holdings of liquid dollar assets by European households contribute to a positive CIP deviation. They hedge these positions by borrowing dollars synthetically, which raises the CIP deviation. A positive ρ also contributes to a positive CIP deviation as European households borrow dollars synthetically to hedge non-asset income. The higher the borrowing of dollars from US households ($\bar{D}_F^{\$}$) or from the Fed through swap

[1] The last term in (B.8) implies a negative relationship between the interest rate differential and the CIP deviation, suggesting that a low interest rate relative to the dollar rate implies a lower CIP deviation. Cross-sectional evidence shows that countries with relative low interest rates have a higher CIP deviation (e.g., Dao, Gourinchas, and Itskhoki, 2025; Du and Schreger, 2022). For our purpose this long-run relationship is not critical as our focus is on the impact of shocks on the CIP deviation. We can set $i^d = 0$ for the main analysis. For a general equilibrium model accounting for the cross-sectional relationship between CIP deviations and interest rates, see Bacchetta and van Wincoop (2025).

lines ($\bar{D}^{\$}_{swap}$), the less the need to borrow dollars synthetically, which lowers the CIP deviation. Assuming that the term in square brackets in (B.8) is positive, a higher value of Γ_{CIP} leads to a higher CIP deviation.

C Linearized Model

When linearizing, we allow for the four offshore dollar funding shocks ($\hat{\psi}$, $\hat{D}^{\$}_{F,1}$, $\hat{D}^{\$}_{swap,1}$, $\hat{\Gamma}_{CIP}$), as well as the other shocks considered in Section 4.3. The latter include shocks to ρ and Γ_F that affect the hedge ratio as well as a shock to Γ_{UIP}.

We first linearize the spot market equilibrium. Using $N^{\$}_{F,1} = M^{\$}_{F,1} - D^{\$,syn}_{F,1} - D^{\$}_{F,1} - D^{\$}_{swap,1}$, the spot market equilibrium (25) can be written as

$$CA^{\$}_{H,1} + dM^{\$}_{F,1} - dD^{\$,syn}_{F,1} - dD^{\$}_{F,1} - dD^{\$}_{swap,1} - S_1 dB^{€}_{UIP,1} = 0 \tag{C.1}$$

In the Online Appendix we show that

$$CA^{\$}_{H,1} = TA^{\$}_{H,1} + i^{\$,syn}_0 D^{\$,syn}_{F,0} + i^{\$} D^{\$}_{F,0} + i^{\$,swap} D^{\$}_{swap,0} + S_1 i^{€} B^{€}_{UIP,0} \tag{C.2}$$

It is equal to the trade account plus four terms that capture net investment income. The first three investment income terms are constant (only depend on time 0 variables). The fourth term depends on S_1. However, we can replace S_1 with S_0 and then add $(S_1 - S_0) i^{€} B^{€}_{UIP,0}$. This is a third-order term, the product of the change in the exchange rate, euro interest rate and euro bond position by UIP arbitrageurs that itself depends on an expected excess return. So we ignore it (we only consider first-order terms). We then have $\widehat{CA}^{\$}_{H,1} = \widehat{TA}^{\$}_{H,1}$.

Regarding the trade account, we have $TA^{\$}_{H,1} = Y_{H,1} - C_{H,1} - C^{o}_{H,1}$. $C_{H,1}$ is held constant and $C^{o}_{H,1}$ is equal to the period 1 profits of Home UIP and CIP arbitrageurs based on period 0 interest rates and portfolio positions. Specifically

$$C^{o}_{H,1} = \left(i^{\$,syn}_0 - i^{\$} \right) B^{\$}_{CIP,0} + (i^{€} - i^{\$} + s_1) B^{€}_{UIP,0} \tag{C.3}$$

Following Itskhoki and Mukhin (2021), we abstract from the effect of s_1 on the consumption of UIP arbitrageurs as this effect is second-order. The last term is the product of an excess return and an expected excess return that determines the euro bond position of UIP arbitrageurs.

We therefore have $\widehat{TA}^{\$}_{H,1} = \hat{Y}_{H,1}$. Using

$$Y_{H,1} = C_{HH,1} + C_{FH,1} + C^{o}_{HH,1} = (1-\omega)\left(C_{H,1} + C^{o}_{H,1}\right) + \omega\left(S_1 P_1^*\right)^{\theta} C_{F,1} \tag{C.4}$$

and $\hat{p}_1^* = -\omega \hat{s}_1$, it follows that

$$\widehat{TA}^{\$}_{H,1} = \hat{Y}_{H,1} = \omega(1-\omega)\theta \bar{C}_{F,1}\hat{s}_1 \tag{C.5}$$

Clearly therefore a dollar depreciation raises the US trade account.

We have

$$\hat{M}^{\$}_{F,1} - \hat{D}^{\$,syn}_{F,1} - \hat{D}^{\$}_{F,1} - \hat{D}^{\$}_{swap,1} = -\hat{\rho} + \frac{\hat{cip}_1 + \hat{s}_1}{\Gamma_F} - \frac{\overline{cip} + i^d}{\Gamma_F}\frac{\hat{\Gamma}_F}{\Gamma_F} \tag{C.6}$$

Next, consider UIP arbitrageurs. We can write

$$-S_1 dB^{€}_{UIP,1} = -S_0 dB^{€}_{UIP,1} - (S_1 - S_0) dB^{€}_{UIP,1}$$

We ignore the last term. It is second-order as it is the product of the change in the exchange rate and the change in the euro position of UIP arbitrageurs. We have

$$-S_0 dB^{€}_{UIP,1} = -\hat{B}^{€}_{UIP,1} = \frac{\hat{s}_1}{\Gamma_{UIP}} - \frac{i^d}{\Gamma_{UIP}}\frac{\hat{\Gamma}_{UIP}}{\Gamma_{UIP}} \tag{C.7}$$

Combining all terms, we can write the spot market equilibrium as

$$\nu_1 \hat{s}_1 + \hat{cip}_1 = shock_1^{spot} \tag{C.8}$$

where

$$shock_1^{spot} = \Gamma_F \hat{\rho} + \left(\overline{cip} + i^d\right)\frac{\hat{\Gamma}_F}{\Gamma_F} + i^d \frac{\Gamma_F}{\Gamma_{UIP}}\frac{\hat{\Gamma}_{UIP}}{\Gamma_{UIP}} \tag{C.9}$$

and

$$\nu_1 = \omega(1-\omega)\theta \bar{C}_{F,1}\Gamma_F + 1 + \frac{\Gamma_F}{\Gamma_{UIP}} \tag{C.10}$$

Next, consider the swap market equilibrium

$$B^{\$}_{CIP,1} = D^{\$,syn}_{F,1} \tag{C.11}$$

From (C.6) we have

$$\hat{D}^{\$,syn}_{F,1} = \hat{\rho} + \hat{M}^{\$}_{F,1} - \hat{D}^{\$}_{F,1} - \hat{D}^{\$}_{swap,1} - \frac{\hat{cip}_1 + \hat{s}_1}{\Gamma_F} + \frac{\overline{cip} + i^d}{\Gamma_F}\frac{\hat{\Gamma}_F}{\Gamma_F} \tag{C.12}$$

We also have

$$\hat{M}^{\$}_{F,1} = \omega \bar{C}_{F,1}\hat{\psi} + \psi(1-\omega)\omega\theta\bar{C}_{F,1}\hat{s}_1 \tag{C.13}$$

and

$$\hat{B}^{\$}_{CIP,1} = \frac{\hat{cip}_1}{\Gamma_{CIP}} - \frac{\overline{cip}}{\Gamma_{CIP}}\frac{\hat{\Gamma}_{CIP}}{\Gamma_{CIP}} \tag{C.14}$$

Therefore the swap market equilibrium becomes

$$\nu_2\hat{s}_1 + \left(1 + \frac{\Gamma_F}{\Gamma_{CIP}}\right)\hat{cip}_1 = shock^{swap}_1 \tag{C.15}$$

where

$$shock^{swap}_1 = \Gamma_F\hat{\rho} + \Gamma_F\omega\bar{C}_{F,1}\hat{\psi} + \left(\overline{cip} + i^d\right)\frac{\hat{\Gamma}_F}{\Gamma_F} + \frac{\Gamma_F}{\Gamma_{CIP}}\overline{cip}\frac{\hat{\Gamma}_{CIP}}{\Gamma_{CIP}} - \Gamma_F\hat{D}^{\$}_{F,1} - \Gamma_F\hat{D}^{\$}_{swap,1} \tag{C.16}$$

and

$$\nu_2 = 1 - \psi(1-\omega)\omega\theta\bar{C}_{F,1}\Gamma_F \tag{C.17}$$

Algebraically, the effect of these shocks is as follows. For the offshore dollar funding shocks we have

$$\hat{s}_1 = \frac{\Gamma_F}{\nu_1\left[1 + (\Gamma_F/\Gamma_{CIP})\right] - \nu_2}\left(-\omega\bar{C}_{F,1}\hat{\psi} + \hat{D}^{\$}_{F,1} + \hat{D}^{\$}_{swap,1} - \frac{\overline{cip}}{\Gamma_{CIP}}\frac{\hat{\Gamma}_{CIP}}{\Gamma_{CIP}}\right) \tag{C.18}$$

$$\hat{cip}_1 = \frac{\nu_1\Gamma_F}{\nu_1\left[1 + (\Gamma_F/\Gamma_{CIP})\right] - \nu_2}\left(\omega\bar{C}_{F,1}\hat{\psi} - \hat{D}^{\$}_{F,1} - \hat{D}^{\$}_{swap,1} + \frac{\overline{cip}}{\Gamma_{CIP}}\frac{\hat{\Gamma}_{CIP}}{\Gamma_{CIP}}\right) \tag{C.19}$$

The denominator of the term in front of the big bracket is clearly positive since $\nu_1 > 1$ and

$\nu_2 < \nu_1$.

For the shocks that affect the hedge ratio we have

$$\hat{s}_1 = \frac{\Gamma_F/\Gamma_{CIP}}{\nu_1\left[1 + (\Gamma_F/\Gamma_{CIP})\right] - \nu_2}\left(\Gamma_F\hat{\rho} + \left(\overline{cip} + i^d\right)\frac{\hat{\Gamma}_F}{\Gamma_F}\right) \tag{C.20}$$

$$\hat{cip}_1 = \frac{\nu_1 - \nu_2}{\nu_1\left[1 + (\Gamma_F/\Gamma_{CIP})\right] - \nu_2}\left(\Gamma_F\hat{\rho} + \left(\overline{cip} + i^d\right)\frac{\hat{\Gamma}_F}{\Gamma_F}\right) \tag{C.21}$$

For the $\hat{\Gamma}_{UIP}$ shocks that only affect the spot market schedule we have

$$\hat{s}_1 = \frac{1}{\nu_1\left[1 + (\Gamma_F/\Gamma_{CIP})\right] - \nu_2}\left(1 + \frac{\Gamma_F}{\Gamma_{CIP}}\right)\frac{\Gamma_F}{\Gamma_{UIP}} i^d \frac{\hat{\Gamma}_{UIP}}{\Gamma_{UIP}} \tag{C.22}$$

$$\hat{cip}_1 = \frac{-1}{\nu_1\left[1 + (\Gamma_F/\Gamma_{CIP})\right] - \nu_2}\nu_2\frac{\Gamma_F}{\Gamma_{UIP}} i^d \frac{\hat{\Gamma}_{UIP}}{\Gamma_{UIP}} \tag{C.23}$$

D Dynamic Model

Here we consider the exchange rate solution from the spot market equilibrium in a dynamic setting. We assume that the spot market equilibrium (25) applies to each period t:

$$CA^{\$}_{H,t} + dN^{\$}_{F,t} - S_t dB^{€}_{UIP,t} = 0 \tag{D.1}$$

In what follows we derive a relationship between the exchange rate and the present discounted value of the CIP deviation. We abstract from shocks to the spot market equilibrium, so that changes in the CIP deviation can be thought of as resulting from offshore dollar funding shocks that only affect the swap market equilibrium. We use the same expressions for these three components of the spot market equilibrium for period t as we have used for period 1 in the 3-period model. We only need to be more precise about the expected change in the exchange rate $E_t s_{t+1} - s_t$. In the 3-period model of the paper, we made an assumption that implies $E_1 s_2 = 0$. Since we now consider a dynamic setting, we leave $E_t s_{t+1}$ as an endogenous variable to be solved. Following Appendix C, we can then approximate the last term of (D.1) as

$$-\frac{E_t\hat{s}_{t+1}-\hat{s}_t}{\Gamma_{UIP}} \tag{D.2}$$

For Foreign households, we use the portfolio expression (15), with one modification. We assume that these agents are not sophisticated enough to predict exchange rate changes and therefore assume $E_t s_{t+1} - s_t = 0$. Under that assumption, and considering the change relative to a pre-shock equilibrium, we have

$$\hat{N}^{\$}_{F,t} = \frac{\widehat{cip}_t}{\Gamma_F} \tag{D.3}$$

Finally, following the results in Appendix C, we have

$$\widehat{CA}^{\$}_{H,t} = \omega(1-\omega)\theta\bar{C}_F\hat{s}_t \tag{D.4}$$

Substituting these into (D.1), we have

$$\lambda\hat{s}_t + \frac{\Gamma_{UIP}}{\Gamma_F}\widehat{cip}_t - (E_t\hat{s}_{t+1}-\hat{s}_t) = 0 \tag{D.5}$$

where $\lambda = \Gamma_{UIP}\omega(1-\omega)\theta\bar{C}_F$. Integrating forward, we have

$$\hat{s}_t = -\frac{\Gamma_{UIP}}{\Gamma_F}\sum_{s=0}^{\infty}\left(\frac{1}{1+\lambda}\right)^{s+1}E_t\widehat{cip}_{t+s} \tag{D.6}$$

The discount rate is close to 1 since λ will generally be close to 0 as the impact of the exchange rate on the trade account is known to be small.

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